Data and Computer Communications

Chapter 6 – Digital Data Communications Techniques

Eighth Edition
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Asynchronous and Synchronous Transmission

- Timing problems require a mechanism to synchronize the transmitter and receiver
  - Receiver samples stream at bit intervals
  - If clocks not aligned and drifting will sample at wrong time after sufficient bits are sent

- Two solutions to synchronizing clocks
  - Asynchronous transmission
  - Synchronous transmission
Asynchronous Transmission

(a) Character format

Unpredictable time interval between characters

(b) 8-bit asynchronous character stream

(c) Effect of timing error
Asynchronous - Behavior

- simple
- cheap
- overhead of 2 or 3 bits per char (~20%)
- good for data with large gaps (keyboard)
Synchronous Transmission

- block of data transmitted sent as a frame
- clocks must be synchronized
  - can use separate clock line
  - or embed clock signal in data
- need to indicate start and end of block
  - use preamble and postamble
- more efficient (lower overhead) than async
Types of Error

- an error occurs when a bit is altered between transmission and reception

- single bit errors
  - only one bit altered
  - caused by white noise

- burst errors
  - contiguous sequence of $B$ bits in which first last and any number of intermediate bits in error
  - caused by impulse noise or by fading in wireless
  - effect greater at higher data rates
Error Detection

- will have errors
- detect using error-detecting code
- added by transmitter
- recalculated and checked by receiver
- still chance of undetected error
- parity
  - parity bit set so character has even (even parity) or odd (odd parity) number of ones
  - even number of bit errors goes undetected
Error Detection Process

Transmitter

Receiver

FEC encoder

FEC decoder

Codeword

Data

k bits

n bits

no error or correctable error

detectable but not correctable error

Chap6.8
Cyclic Redundancy Check

- one of most common and powerful checks
- for block of $k$ bits transmitter generates an $n$ bit frame check sequence (FCS)
- transmits $k+n$ bits which is exactly divisible by some number
- receiver divides frame by that number
  - if no remainder, assume no error
Error Correction

- Correction of detected errors usually requires data block to be retransmitted
- Not appropriate for wireless applications
  - Bit error rate is high causing lots of retransmissions
  - When propagation delay long (satellite) compared with frame transmission time, resulting in retransmission of frame in error plus many subsequent frames
- Instead need to correct errors on basis of bits received
- Error correction provides this
Error Correction Process

The diagram illustrates the error correction process as follows:

- **Transmitter**:
  - Data ($k$ bits) is encoded by a FEC encoder.
  - The encoded data forms a codeword ($n$ bits).

- **Receiver**:
  - The received codeword is decoded using the FEC decoder.
  - If no error or correctable error is detected, the data is extracted.
  - If a detectable but not correctable error is detected, the data is discarded.

The flowchart emphasizes the process of encoding data to ensure transmission reliability and decoding it accurately at the receiver end.
How Error Correction Works

- adds redundancy to transmitted message
  - effective data rate is reduced
- can deduce original despite some errors
- eg. block error correction code
  - map $k$ bit input onto an $n$ bit codeword
  - each distinctly different
  - if get error assume codeword sent was closest to that received
Example 6.9

For $k=2$ and $n=5$,

- Data Block | Codeword
  - 00        | 00000
  - 01        | 00111
  - 10        | 11001
  - 11        | 11110

- A block of 00100 is received
  - An error will be detected
  - 00000 will be assumed to be the corrected codeword
Line Configuration - Topology

- physical arrangement of stations on medium
  - point to point - two stations
    - such as between two routers / computers
  - multi point - multiple stations
    - traditionally mainframe computer and terminals
    - now typically a local area network (LAN)
Line Configuration - Topology

(a) Point-to-point

(b) Multipoint
classify data exchange as half or full duplex

- half duplex (two-way alternate)
  - only one station may transmit at a time
  - requires one data path
- full duplex (two-way simultaneous)
  - simultaneous transmission and reception between two stations
  - requires two data paths
    - separate media or frequencies used for each direction
  - or echo canceling
Summary

- asynchronous verses synchronous transmission
- error detection and correction
- line configuration issues